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METHOD OF DECREASING NO_x IN COMBUSTION EXHAUST GAS

[NENSHOUHAIGASUCHUU NO NO_x TEIGENHOU]

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1. Title of the invention

Method for decreasing NOx in combustion exhaust gas

2. Claims

- 1) A method of decreasing NOx in combustion exhaust gas characterized by adding pulverized charcoal of a fuel ratio of ≤ 1.8 followed by addition of air to remove the unburnt fraction.
- 2) A method of decreasing NOx in combustion exhaust gas characterized by adding pulverized charcoal of a fuel ratio of ≤ 1.8 to the exhaust gas of main combustion by employing recycled combustion exhaust gas as carrier gas, followed by addition of air to remove the unburnt fraction.

3. Detailed Description of the Invention

The present invention relates a method of decreasing the nitrogen oxides NOx in the combustion exhaust gas, in particular a method of decreasing NOx with a simple device without using catalyst.

Conventionally, for preventing air pollution due to combustion exhaust gases, denitrification process using

catalyst was developed and applied, but the high cost of installation have led to problems of equipment cost, operation cost, location (space) etc. In particular, when adding denitrification equipments to existing plants, it is extremely difficult to manage space. Furthermore, with combustion exhaust gases using coal as the fuel, dust is contained in very large amounts, problems also such as catalyst abrasion, choking etc., will also begin to occur.

The present inventors carried out extensive studies aiming at developing a simple device for decreasing NOx by focusing mainly on combustion exhaust gas from thermal power station that use coal as fuel, and comparing with said catalyst-based denitrification method, and discovered that by adding 5-20% (calorific value basis) of pulverized coal of fuel ratio (fixed carbon amount/ash fraction by industrial analysis of coal) of ≤ 1.8 based on the fuel, particularly pulverized coal, to the post-combustion exhaust gas containing small amounts of oxygen, reduction in NOx is possible, and accomplished the present invention.

The present invention is described below with the help of Fig. 1 depicting a concrete embodiment.

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Fig. 1 shows a boiler furnace body used in usual thermal power generation. 2 is the main burner, and as

fuel are employed natural gas, petroleum fuels such as heavy oil etc., and coal etc. However, the explanation below shall focus on the case of using pulverized coal which is the main object of the present invention. 3 is an air injection line for injecting the so-called over-fire air for low NOx combustion. With such a conventional combustion method, in zone a, along with SO₂, CO₂, H₂O and N₂, 0.5-4% of O₂ and though also related to the fuel and combustion method, generally about 100-350 ppm of NOx exists. In this, NOx is one of the main materials responsible for causing the so-called air pollution of photochemical smog, and must be decreased as much as possible before it reaches the chimney.

In the present invention, pulverized charcoal of fuel ratio of ≤ 1.8 is charged through the line 4, and the NOx in zone b is reduced. The amount of pulverized coal added is 5-20% (calorific value basis) of main combustion quantity, and here, the NOx is converted to the non-polluting N₂ by the following reactions.

- 1) reduction in NO due to the hydrocarbons vaporized from the pulverized coal,
- 2) reduction in NO due to the NH₃, HCN etc., formed by the dry distillation and gasification of the pulverized coal,

3) reduction in NO due to the char formed from the pulverized coal

In the said reactions 1)-3), many operating factors are concerned. That is, the characteristics of pulverized coal (fuel ratio, N content etc.), residual O₂ concentration after main combustion, and type of the carrier gas for added pulverized coal, etc. As a result of extensive studies on these aspects by the present inventors, it was found that these effects can be remarkably improved by discovering that materials having relatively high volatile fraction with respect to the fixed carbon (that is, materials of low fuel ratio) are useful for this purpose, and further, use of recycled combustion exhaust gas as carrier gas when using coal of low fuel ratio.

The said effect 1) increases with increasing volatile fraction in the coal (that is, coal of low fuel ratio), and on the contrary, the effect 3) increases with increasing fixed carbon fraction. Therefore, considering from the experimental results (see later) of the present inventors, the effect of 3) on denitrification reaction may be said to be stronger than that of 1), and this may be the reason for the denitrification effect of coal of low fuel ratio. Further, regarding the effect of recycled combustion exhaust gas as carrier gas, its low content of O₂

(generally, it is 0.5-4%) may be thought to accelerate the effect of 2). That is, while NH_3 and HCN have the effect of reducing the NO_x , they are also the sources for NO_x generation, and for functioning in the direction of NO_x reduction rather than NO_x generation, it is desirable therefore to have lower O_2 concentration in the zone where the added pulverized coal contacts with the combustion exhaust gas main flow. In fact, when air was used as the carrier gas with a coal of high fuel ratio, it was found that the NO_x concentration increases, on the contrary, compared to that in zone a based on the operating conditions.

Then, reduction substances will be in excess in zone b, and contains fair amounts of unburnt CO , and HC (hydrocarbons) etc. Therefore, by charging air from line 5 for removing unburnt fraction, and it is necessary to ensure complete combustion. In zone c, along with combustion of unburnt fraction, though part of the nitrogenous compounds (NH_3 , HCN etc.) will be transformed to NO_x , overall it becomes possible to decrease the concentration of NO_x to a fair degree. The NO_x thus formed in the zone a decreases to about 4.0-7.0 and, by becoming a clean exhaust gas, discharged from the boiler. Moreover, denitrification effect is obtained and the unburnt fraction

also does not remain if the exhaust gas temperatures at the pulverized coal charging point from line 4 and at the charging point of air from line 5 for removal of unburnt fraction are above 1000°C and above 900°C respectively. It is advantageous to employ these temperature zones in the actual boiler.

Example

Tests were carried out on the combustion exhaust gas using pulverized coal as fuel. In Fig. 2 is shown the flow sheet of the test equipment.

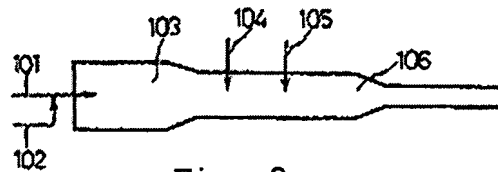


Fig. 2

In the drawing, **101** is the feed line for fuel pulverized coal and primary air feed line, **102** is feed line for secondary air for combustion use, and **103** is the furnace. For the exhaust gas after combustion, pulverized coal from line **104** and air from line **105** for removal of unburnt fraction were charged, and part of the exhaust gas with reduced NO_x amount resulting from these operations was withdrawn from chimney **106**, and analyzed.

The test conditions are shown below.

The main fuel was the pacific coal, and the combustion

amount was a constant 100 Kg/H. Investigations were carried out employing 7 types of pulverized coals, namely,

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coal A - coal G, for charging from line 104 (their characteristics are shown in Table 1). The addition amount was constant at 13% of main combustion amount (calorific value basis), and the exhaust gas temperature at the charging point was constant at 1400°C. Further, the exhaust gas temperature at the charging point of air from line 105 for removal of unburnt fraction was 1250°C.

Table 1

Coal	Fuel ratio	N content in coal	Origin
Coal A	0.94	1.03 %	Japan
Coal B	1.12	1.10	Japan
Coal C	1.56	1.12	Japan
Coal D	1.79	1.64	South Africa
Coal E	1.89	1.50	Australia
Coal F	2.36	0.90	China
Coal G	2.65	1.10	America

The air feed quantity from line 105 was adjusted such that from the combustion in the furnace 103, 145 ppm of NOx

was formed, the residual oxygen concentration was 1.3%, and the oxygen concentration in the exhaust gas at chimney 106 was 4.0%. Further, at each test condition also, regarding the gas analysis of NO_x, CO and O₂ for the gases in which emission of CO was not detected (5 ppm or less). Continuous measurements were made by chemoluminescence method, non-dispersive infrared method and zirconia cell method respectively. Tests were carried out for respective coals for the case when air was charged from line 104 as a carrier gas of pulverized coal, and for the case where recycled combustion exhaust gas (O₂ concentration 4%, and the recycle amount was 10% of the entire exhaust gas. The amount was same even when air was used as the carried gas).

The test results are shown in Fig. 3. In the diagram, **A** is the case when air was used as a carrier gas, and **B** is the case where recycled combustion exhaust gas was used as

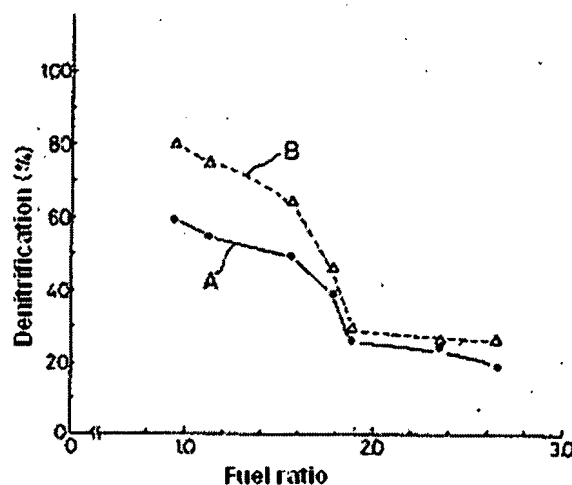


Fig. 3

the carrier gas. From the diagram, it is evident that excellent denitrification effect is obtained by the addition of pulverized coal from line 103, and for the coals (coals of fuel ratio of 1.8 or less), the effect of recycled combustion exhaust gas as carrier gas is remarkable.

Next, test were carried by changing several coal types, and pulverized coal charging temperature in the range of 1100-1520°C, but there was no change in the trend.

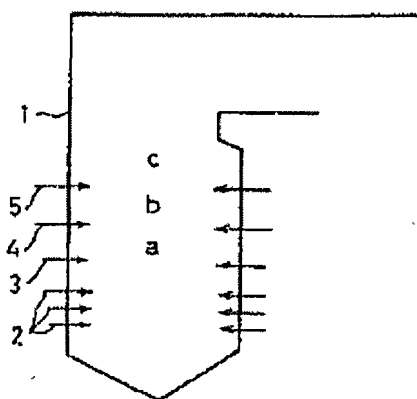
AS described above, the method due to the present invention is extremely useful as a method of reducing the NOx content in combustion exhaust gas using coal is principal raw material, wherein the developments are being done in earnest in various aspects. Further, from the principle of the present invention, it is needless to say that it can be applied in an absolutely similar manner even for fuels where the principal fuel is fuel oil, gaseous fuels etc.

4. Brief description of drawings

Fig. 1 is the flow sheet depicting a concrete embodiment of the present invention, Fig. 2 is a flow sheet of a test device showing the utility of the present invention, and Fig. 3 shows an example of the test results

of the present invention.

※ 1 図



※ 2 図

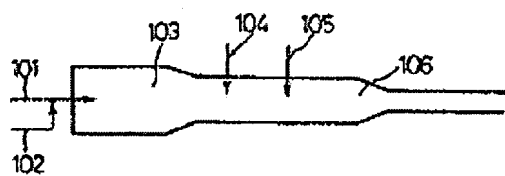


图 3

